CURRENT MEASURING APPARATUS AND METHODS

FIELD OF THE DISCLOSURE

[0001] The described technology generally relates to measuring current and, more specifically, to apparatus and methods that involve measuring current flowing through a wire using magnetic sensors.

BACKGROUND

[0002] Accurate measurement of current through a wire remotely (e.g., without breaking the wire or coming into contact with it) is useful for diagnostic, operational, and protection purposes in many applications, such as industrial and automotive applications. In particular, accurate current measurement without precise control of the placement of the wire may present various challenges. It can also be challenging to accurately measure current through the wire remotely when there are other current carrying wires located nearby as the current flowing though such wires can interfere with the desired current measurement. One commonly used technique for alternating current (AC) measurements is using a Rogowski coil, which does not depend on the precise location of the wire inside the coil. However, Rogowski coils cannot make direct current (DC) measurements and can be too bulky for use in tight spaces.

SUMMARY OF THE DISCLOSURE

[0003] The systems, methods and devices of this disclosure each have several innovative aspects, no single one of which is solely responsible for the all of the desirable attributes disclosed herein. Details of one or more implementations of the subject matter described in this specification are set forth in the accompanying drawings and the description below.

[0004] Sensors may be positioned around an opening for a wire to measure the current flowing through the wire. A non-symmetric positioning of the sensors around the target measurement zone can enable an expanded measurement zone compared to conventional current measurement devices. Further, some sensors may be paired such that a hypothetical line connecting the sensors is tangential to the target measurement zone. Other sensors may be paired such that a hypothetical line connecting the sensors crosses the target measurement zone. The different pairing of the sensors enables a reduction in the impact of stray field interference on the measurement of the current flowing through the target wire under measure. The sensors may have multiple distances from the center of the measurement region creating a design with multiple radius lengths. The multiple radii enable an increase in accuracy in the target region and allow a wider dynamic range of currents to be measured.

[0005] Certain embodiments of the present disclosure relate to an apparatus for measuring current flow through a wire. The apparatus may include a housing with an opening configured to receive a wire. The opening may correspond to a target measurement zone for measuring a current flowing through the wire when the wire is positioned within the opening. The apparatus may further include a first pair of magnetic sensors within the housing that may be positioned such that a line between the magnetic sensors of the first pair is substantially tangential to the target measurement zone. Further, the apparatus may include a second pair of magnetic sensors within the housing that may be positioned such that a line between the magnetic sensors of the second pair crosses through the target measurement zone. Moreover, the apparatus may include a hardware processor in communication with the first pair of magnetic sensors and the second pair of magnetic sensors. The hardware processor may be configured to derive a measure of the current flowing through the wire based on outputs from the first pair of magnetic sensors and the second pair of magnetic sensors.

[0006] Additional embodiments of the present disclosure relate to a method of measuring current through a wire. The method may include calculating a first differential signal value based at least in part on output signals from a first pair of magnetic sensors and calculating a second differential signal value based at least in part on output signals from a second pair of magnetic sensors. Further, the method may include deriving a measure of current flowing through a wire positioned within a target measurement zone based at least in part on the first differential signal and the second differential signal, so as to reduce an impact of one or more stray fields on the measure of current relative to using one of the first differential signal or the second differential signal.

[0007] Some embodiments of the present disclosure relate to an apparatus for measuring current flow through a wire. The apparatus may include a housing with an opening configured to receive a wire. The opening may correspond to a target measurement zone for measuring a current flowing through the wire when the wire is positioned within the opening. The apparatus may further include a first set of sensors positioned a first distance from a center point of the target measurement zone and a second set of sensors positioned a second distance from the center point of the target measurement zone. Further, the apparatus may include a hardware processor in communication with the first set of sensors and the second set of sensors. The hardware processor may be configured to derive a measure of the current flowing through the wire based on outputs from the first set of sensors and the second set of sensors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Throughout the drawings, reference numbers are re-used to indicate correspondence between referenced elements. The drawings are provided to illustrate embodiments of the subject matter described herein and not to limit the scope thereof.

[0009] FIG. **1**A graphically illustrates a measurement zone for measuring the current in a wire for some current measurement systems.

[0010] FIG. **1**B graphically illustrates the region of accuracy in the measurement zone of FIG. **1**A for some current measurement systems.

[0011] FIG. **2** is a block diagram illustrating an example current measurement system in accordance with certain embodiments.

[0012] FIG. **3** is a block diagram illustrating an example apparatus for measuring current in accordance with certain embodiments.

[0013] FIG. **4** illustrates a placement of sensors within an example apparatus for measuring current in accordance with certain embodiments.

[0014] FIG. **5** graphically illustrates a placement of sensors for measuring current in accordance with certain embodiments.